by foods, Dr. Corfield stated that in 1871 he was called on to inspect the house at which His Majesty (then Prince of Wales) was supposed to have contracted typhoid fever, and reported the results of his investigations in a letter which appeared in the *Times* of January 22, 1872, in which he showed that, although there were certain sanitary defects in the house in question, there were no such defects as had been previously described. For instance, it had been said that the water-closet in their Royal Highnesses suite of apartments was directly connected with a cesspool beneath them, and that its soil-pipe was not ventilated. Neither of these statements was true; there was no cesspool under the water-closet at all, nor, indeed, anywhere on the premises, and the soil-pipe was fully ventilated. There was, in fact, nothing the matter with that water-closet, and it is certain that His Royal Highness did not get his attack of fever from any foul air in it. There was, however, a defect in a water-closet in the middle of the house, and he was unable to say positively that the outbreak of the disease was not due to defective sanitary arrangements. On looking through his notes, made some thirty years ago, he had come to the conclusion that, although it was proved that the outbreak was not caused by water or milk, it was in all probability caused by some other food (such as oysters or salad) which was partaken of by His Royal Highness, the other gentlemen of the party and some of the menservants (among whom all the cases occurred), perhaps at a shooting luncheon, but not by the Princess of Wales, or by any of the other ladies or female servants. Had the outbreak been caused by the insanitary condition of the premises, it would certainly have attacked some of those who were most in the house, whereas it attacked those who were most out of doors and some of those who did not sleep in the house at all.

He then described cases in which the disease had been distributed by means of sewer air and by the washing and mangling of clothes. The questions of ground water and of direct infection were also considered. An account was given of the behaviour of the typhoid bacillus in various circumstances, and the lecture concluded with a reference to the prevalence of typhoid fever in South Africa and its probable dissemination by means of dust and flies, as well as by water, and with some tables of statistics showing the great diminution of the death-rate from the disease in England and Wales, and also in Paris, during recent years. The increase of the disease in Paris during the years 1899-1900 was not peculiar to that city, as it was shared by London and England generally, and it was only heard of because the Paris Exhibition was held in 1900.

EVOLUTION AND ITS TEACHING.[1]

EVER since the dawn of the human intellect, man has tried to increase his knowledge in two ways, by observation and by speculation. Observation came first, for that is common to man and animals. Speculation is a distinctly human attribute, and we find that it soon out-distanced observation, and formed the basis of the earlier philosophies. But during the last few centuries, the observational method has once more come to the front under the name of science, and its conclusions have not always been in accord with those of the speculative philosophies which preceded it.

The difference between the two methods is that whereas speculation starts a chain of reasoning from one or two propositions which are taken as absolutely true, science reasons from the basis of as large a number of observations as possible, and tries to find a hypothesis which connects them all together; or explains them, as it is usually called.

An Outline of Evolution.

The idea of evolution originated with the Greeks, but only as a speculation, which led to nothing; and its scientific history may be said to commence in the early part of the last century, when the practically new theory of the origin of species by gradual development was proposed by Lamarck. This theory was at first discredited for lack of evidence; but it was developed and demonstrated by Darwin in the middle of last century. About the same time it was pointed out by Lord Kelvin that not only was the sun cooling, but that all kinds of energy, when converted into heat, lost a portion by radiation into space, and that this process must go on until the whole universe was of a uniform temperature. So that, although the amount of energy in the universe remains unalterable, it will, by redistribution, be brought into the potential state, and thus, when every possible action is counterbalanced by other actions, energy will practically disappear.

From this theory of "dissipation of energy" it follows that as the earth is cooling, life cannot go on for ever; and also that at some former time the earth must have been too hot for the existence of protoplasm. Consequently, life can only have a limited existence on the earth. It must have had a beginning, and must come to an end.

But the inference extended further. Not only living beings, but even the whole solar system must have had a beginning, not indefinitely remote; because most of its members still contain a large amount of their original heat. And if the solar system had a beginning, so also must each star in the heavens have had a beginning; for the very fact that we can see them is a proof that they are radiating out energy. And, it was asked, why should not the whole universe, visible and invisible, have had a common origin and a common beginning in time? This had been the opinion of Immanuel Kant in the middle of the eighteenth century, and although modern astronomy has not altogether confirmed his speculations, it has proposed a hypothesis which is not very dissimilar. This is the "meteoritic hypothesis," and is chiefly the work of Sir Norman Lockyer and Prof. G. H. Darwin. I will give you a short sketch of the views held by the former.[1]

Inorganic Evolution.

The close connection between the orbits of comets and those of meteoritic streams has led to the universally admitted conclusion that comets are neither more nor less than swarms of meteorites. Again, the resemblance between the spectra of comets and those of nebulæ suggests that these also are swarms, or aggregations, of meteorites. And we naturally infer that the stars with similar bright-line spectra must be collections of meteorites. From bright-line stars we pass to those of which the meteoritic origin is no longer to be recognised, all having blended together. Further, it is claimed that by supposing variable and temporary stars to be due to the meeting and entanglement of two meteoritic swarms we get a better explanation of the observed phenomena than any other hypothesis can give.

This meteoritic hypothesis supposes that the present material universe was at one time in a state of "cosmic dust," spread irregularly through space, and moving slowly in many directions. It is the original irregular distribution of the cosmic dust and its irregular movements which are the source of all the energy in the universe. We have specimens of this cosmic dust in the chondroi, or spherules, of which many of the stony meteorites are built up. They are small round bodies of crystallised minerals, varying from microscopic dimensions to the size of a marble. Of course, these chondroi are not the first form in which matter existed. They are evidently due to chemical reactions, and we could frame several different hypotheses as to their origin and history. But these would be speculations which could not, at present, be verified, and so we must content ourselves with the chondroi as the earliest form of matter known to us.

Through the action of gravitation, much of the cosmic dust is supposed to have aggregated into meteorites, the irregular movements of which were, in certain places, reduced to order; and so arose a number of meteoritic streams, or swarms, moving through space. Still, under the force of gravitation, each of these swarms got more and more dense, until, at last, collisions took place between the meteorites; light and heat were given out, and the swarm became a nebula. The heat produced by the collisions would, at first, be slight, but would gradually increase, until the whole of the solid material was resolved into vapour and a star was formed. Concentration, however, would still go on, and the temperature of the star would rise until, in time, the loss by radiation more than counterbalanced the gain by concentration, when the star would begin to cool. At last light would no longer be given off, and the star would end by becoming a dark cold body moving in space. Of course, some stars would attain a higher maximum temperature than others, and either a single or a double star might be the result of the condensation; but all would follow a somewhat similar development.

[1] Abridged from an inaugural address, delivered before the Australasian Association for the Advancement of Science, by Captain F. W. Hutton, F.R.S., president, on January 8.

[1] See "The Meteoritic Hypothesis" (Macmillan, 1890); and "Inorganic Evolution" (Macmillan, 1900).

Now, as a matter of fact, the spectroscope shows us that stars in all these stages actually exist at the present day in the heavens. In some the temperature is increasing, in others it is decreasing, and, although small stars must run through their development quicker than large ones, this is quite insufficient to account for all the present differences. From which it follows that some of the stars are much older than others. The sun was amongst the earliest of formed stars. When it was born, the sky must have presented an almost uniform blackness. There was no Milky-Way; no Orion or Southern Cross; no Pleiades or Dog Star. All these, and many others, have been added since; not altogether, but one after the other, through the long ages during which the sun was undergoing development. Judging by the relative ages of the stars, it seems probable that the process of concentration of the original cosmic dust commenced near the solar system and spread outwards to the Milky-Way. But, however this may be, the process is not yet over. Many nebulæ have not yet condensed into stars. Swarms of meteorites still traverse space, and, even in the neighbourhood of the solar system, they are so abundant that the earth alone is estimated to collect more than twenty millions each day.

However, slow as the process of condensation is, it is not endless. In time all the meteoritic dust will be collected into stars or planets, and in time the law of dissipation of energy will bring all these bodies to a uniform temperature. So at last the movements due to the original unequal distribution of matter will cease and the life of the universe will come to an end. We know of no process of rejuvenescence by means of which dissipation of energy, and the force of gravitation, might be counteracted. Several attempts have been made to refute the theory of dissipation of energy, but all have failed. The ether which pervades space is the only part of the universe which shows no sign of evolution. It alone remains unchanged.

A casual glance at the stars gives us the impression of immutability. We still speak of the fixed stars in much the same way as our forefathers used to speak of the everlasting hills. But we know that they are not fixed. We know that the nearer stars, including the sun itself, are in swift movement; and we infer that all are so. But we can see no connection between their movements. Single stars, or small groups of stars, are rushing through space in various directions, and we cannot detect any common centre of gravity which holds them in control. The stars have not yet attained the regularity of movement that gravitation must bring about in a very ancient system, and this idea of the comparative youth of the universe is strengthened when we remember that large numbers of the primitive meteorites are still wandering in space uncondensed into stars. If it be true that the sun is one of the oldest stars in the universe, and if, as geologists think, the earth is not more than a hundred millions of years old, then it may very well be that the creation of the cosmic dust out of which the stellar universe has been formed took place less than two hundred millions of years ago. But although it may be possible to place a limit to the age of the universe, we can fix no time for its duration. It is impossible to form an estimate of the hundreds of millions of years that will pass before the end approaches. Still, a time must come when all energy will be equilibrated, and when, possibly, the visible universe may resolve itself into invisible, motionless ether.

In the solar system we can study the development of a meteoritic swarm in greater detail. Here we find that the whole of the meteorites did not collect into a single mass, but that several planets, as well as the sun, were formed simultaneously. It has been shown by Prof. G. H. Darwin that the effect of many collisions among a swarm of meteorites would be gradually to eliminate orbits of great eccentricity until, in time, a regular system would be developed, when the whole of the meteorites would travel nearly in the mean plane of their aggregate motions. The larger of the meteorites would tend to settle towards the centre, while other aggregations might easily occur at different distances from the centre. And of these the outer planets would be larger than the inner ones, because in the more distant regions, where the attraction of the central sun was less, the movements of the meteorites would be slower, and there would be a greater tendency to agglomeration than where the movements were more rapid. As meteorites contain but little oxygen, hydrogen, carbon, silicon and alkalis—substances which are all abundant on the surface of the earth—large numbers must have been fused together to form the earth, and the lighter substances must have collected near the surface. Consequently, the collisions between these meteorites must have occurred with sufficient rapidity to melt the whole mass. For after a solid crust had been formed, all the meteorites which fell on the earth would remain on the surface as they do now.

As with the solar system, so, also, in the earth itself we can trace distinctly a physical evolution. The discovery of tidal friction gave an independent proof that the earth had had a beginning not infinitely remote, for if that had been the case, the tidal friction would have reduced the time of the earth's rotation on its axis to that of the moon. Also we have sufficient geological evidence to show that not more than one hundred millions of years ago the earth was in a molten condition, and, probably, shone with its own light. As cooling went on, the silicates crystallised out, forming a solid crust over the still molten, metallic interior, the earth then becoming a dark body. At that time all the water above the crust was in a state of vapour which, subsequently, fell as hot rain, forming a boiling ocean. With this rain the denudation of the primitive crystalline rocks commenced, and their débris was deposited on the bed of the ocean as sedimentary rocks. Gradually the continents were formed, the new ranges of mountains following each other in orderly succession, the great oceans becoming narrower and deeper as well as more and more salt. These processes are still going on, but, as the earth is cooling, the internal energy which uplifts the mountains must be diminishing, and in time it will be insufficient to counteract the denudation. Then the whole of the land will be swept into the sea, and the waves of the ocean will roll over the surface of the earth unopposed; unless, indeed, before that time arrives the ocean should have been frozen into a mass of ice, or should have sunk slowly into the ground. All these things are approaching, but which of them will come first it is impossible to say.

Organic Evolution.

When, during the course of physical evolution, the ocean had become sufficiently cool for the existence of protoplasm, minute living organisms appeared on its surface. These increased in size, varied in many directions, and, in time, discovered the bottom of the sea, on which they established themselves, changing from swimming to crawling creatures. Gradually these organisms managed to live in safety among the rough waters of the sea coast, and then they spread over the land, first the plants and then the animals, which came to feed on the plants.

Once established on land and breathing air, improvements in the circulatory system of the higher animals became possible. The purified blood was kept separate from the impure blood, and increased rapidity of physiological processes heated the body, so that, in the birds and mammals, a stream of pure, warm blood was poured upon the brain. Thus stimulated, the brain developed rapidly, and the psychological evolution, thus inaugurated, has reached such a height in man as to place him mentally apart from the rest of the animal kingdom.

Biological evolution differs from physical evolution in being brought about by the transmission of bodily variations from one generation to another. And in psychological evolution, mind is transmitted from parent to offspring, as well as the organ in which it is to be manifested. Intelligence, however, depends, not only on the structure of this organ, but on early associations and education, by which means the wisdom of one generation is handed down to the next.

Psychological evolution consists of two parts. The first is intellectual, and is found in all the higher animals as well as in man. The second is ethical, and is exclusively human.

Intellectual evolution, like biological evolution, is due to competition between different individuals and the action of selection. We probably see the first germs of ethical evolution in parental affection, which, among gregarious animals of sufficient intelligence, widened into social sympathy, and this, in man, gave rise to the social or civic virtues.

This advance also appears to have been, or, at any rate, may have been, due to selection, and the result was the emergence of what is called utilitarian morality. Morality, in the strict sense of the term—that is, formal morality—also appears to have arisen from sympathy, but not by means of selection. The long and constant use by man of formal morality has made it instinctive, and has thus given rise to the conscience.

Secondary Causes.

When we think of the whole work that has been accomplished by evolution we are overwhelmed by its vastness. The results of organic evolution, particularly, are so marvellous that, to our

limited intelligence, the forces to which they are due seem to have been constantly directed in their course. The human mind is more disposed to accept the idea of guidance than that of predetermination, as it seems to us to be the less impossible of the two, and the more easy to understand. We ourselves wait upon circumstances; we see how things are going to shape before we move, and we fancy that the world must have been made, and must be carried on, on the same principle. But the study of nature gradually causes this belief to fade away. The more we learn the more we see that secondary law extends much further than we had expected, and we begin to think that all may be due to secondary laws.

We cannot doubt but that the most complicated cases of inheritance—such as the growth of the train feathers of a peacock, or the gorgeous wings of a butterfly—are due to secondary laws, although the processes are quite incomprehensible to us. We believe these to be due to secondary laws, because we see them taking place in exactly the same order over and over again; and in the case of the peacock we know that if we pull out the feathers, new ones, similar to the old, will replace them. So that we can bring these laws into play whenever we choose. It is not sufficient, therefore, to say that an action is not due to secondary law, because it is so wonderfully intricate, or because it is incomprehensible to us. We must be able to show, either that the action is antagonistic to known natural laws, or that the result could not be due to a combination of any natural laws that we have already discovered. That is, we must show a discontinuity in the phenomena. Can any such breaks be discovered?

The origin of the material universe, which was the starting point of the present evolutionary process, appears to us to have been a new departure in natural law. But we cannot feel certain about it, for we do not know, and never can know, what went before. But with the origin of life on the earth it is different. The intimate structure of organic beings, as well as their order of development on the earth, point to the conclusion that they are all derived from a common ancestor, and that living protoplasm was formed once, and once only, on the surface of the sea. Now, in the origin of living substance on this planet we have a case which is generally recognised as a break in continuity. It is generally allowed that it was an action which is not only incomprehensible by us, but one which conflicts with our knowledge of natural laws. That an unstable chemical compound, endowed with the power of directing energy independently of any outside agent, should have been brought into existence by the action of known physical laws is an impossibility. The processes of assimilation and fission, on which all progress depends, are quite distinct from anything which had gone before. And as every living cell is imbued with what we call instinct, which directs its energies, it follows that in physiology action and reaction are not equal and opposite. Indeed, every organism inherits from its parents a store of energy which directs growth and which appears to be inexhaustible. It is drawn upon during the whole period of growth, which, in some plants, lasts all through life, and yet abundance is left for transmission to its offspring, no matter how numerous they may be. The store increases instead of diminishes, and we cannot tell why. Until some explanation can be given, it is not only permissible, but reasonable, to view the origin of life as due to some guiding action of natural law, especially when we remember what that break in continuity has led to.

Again, it has been often pointed out that the genesis of consciousness is as great a mystery as the genesis of life, and that it seems to be equally opposed to the law of conservation of energy. In the lower animals, and in some of the lowest plants, we see physiological processes producing movements which appear to be intelligent, but which, in reality, are no more so than the movements of the leaves of a sensitive plant. And it is generally allowed that for the exhibition of consciousness a brain-cortex is required; but how matter in the brain-cortex becomes self-conscious we cannot understand. However, it is possible to suppose that mind is a necessary concomitant of life, so that the origin of the two may be one and the same problem. Also, as consciousness may be lost—as in habit—and regained by attention, it is possible that consciousness may be a constant function of mind, but one that cannot become efficient until a large number of specially formed cells are accumulated in a brain-cortex. I cannot, therefore, see that the genesis of consciousness in animals necessarily marks a break in continuity, notwithstanding that its origin is quite incomprehensible to us.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Proposals have been laid before the Senate for modifying the principles of classification in the natural sciences tripos, though the proposals are not unanimously acquiesced in by the boards concerned. In part i., in which at present the aggregate mark in three or four sciences governs the class, it is suggested that weight should also be given to the candidate's particular performances in each subject. In part ii., a candidate is required, for a first class, to take at least one primary and one subsidiary subject; it is proposed to abolish the requirement of a subsidiary subject. It is further proposed that human anatomy and vertebrate comparative anatomy should in future be reckoned as a single subject in this part of the tripos. These changes, if approved, are to come into effect in 1904.

Earl Spencer, K.G., has been appointed an elector to the professorship of agriculture in the place of the late Sir J. H. Gilbert, F.R.S.

UNDER the will of the late Dr. Nathaniel Rogers, the Senate of the University of London offer a prize of 100*l.*, open for competition to all the members of the medical profession in the United Kingdom, for an essay on "The Production of Immunity in Specific Infective Diseases—generally, and with particular Reference to any one Disease on which the Writer of the Essay may have made Original Investigations." Essays must be sent in not later than February 28, 1903, addressed to Mr. Percy Wallace, secretary to the Senate.

THE report of the executive committee of the Carnegie Trust for the Universities of Scotland on the administration of the trust for the period from June 7, 1901, to December 31, 1901, was read and passed at a meeting of the trustees last week. For the winter session 1901–2, the sum of 22,941*l.* 16*s.* 6*d.* was paid by the trust up till December 31, 1901, on behalf of 2441 students, representing the fees of 7610 classes. The committee, in accordance with the expressed desire of Mr. Carnegie, did not make question respecting the circumstances of applicants; but from information voluntarily offered by applicants themselves, they have ample assurance that in a large number of cases the payment of class fees has proved a boon of the greatest value to deserving students, and many acknowledgments of the letter sent to the parents and guardians of applicants express gratitude for the timely assistance rendered by the Trust. The class fees paid and the number of students were as follows:—St. Andrews, 268 students, class fees, 2452*l.* 16*s.*; Glasgow, 828 students, class fees, 7672*l.* 13*s.* 6*d.*; Aberdeen, 473 students, class fees, 3806*l.* 1*s.* 6*d.*; Edinburgh, 872 students, class fees, 9010*l.* 5*s.* 6*d.*

MR. J. H. GARTSIDE has given to the Owens College, Manchester, the sum of 10,000*l.*, which has been applied in the purchase of an annuity of 1163*l.* a year for ten years, payable to the college, to be used for the provision of scholarships, which are to be known as "The Gartside Scholarships of Commerce and Industries." The scholarships are intended to induce young men who have already received a good education to devote a year at least in Owens College to the special study of subjects bearing on commerce and industry, and then to go abroad for the study of some particular subject, either in Germany or the United States, or some other country approved by the electors to the scholarships. The emoluments of the scholar while in England will be about 80*l.* a year, but when travelling abroad a larger sum will be given, which in the case of scholars travelling in the United States will probably be about 250*l.* per annum. The scholars are to furnish reports of their investigations in the foreign countries which they visit. These scholarships are intended by Mr. Gartside to be an incentive and assistance to those who contemplate a careful study of commercial and industrial methods, and should enable useful information to be obtained with regard to these subjects, both in America and on the Continent.

AT the annual general meeting of the members of University College, London, held last week, Lord Reay moved the following resolution on behalf of the council:—"That this meeting has heard with great satisfaction of the generous offer of the Drapers' Company to make themselves responsible for the debt upon the college to the extent of 30,000*l.*, and of another friend